

METHOD FOR OPERATING A POSITION-MEASURING DEVICE AND  
POSITION-MEASURING DEVICE SUITABLE TO THAT END

The present invention relates to a method for operating a position-measuring device, as well as a position-measuring device suitable to that end.

5 In position-measuring devices which are used in the automation sector, data is often transmitted between the position-measuring device and a downstream sequential electronics via digital, serial interfaces. In this context, on the side of the position-measuring device, an architecture is provided  
10 such that it includes a signal-generating unit which is connected to a communication unit via an internal interface unit. The communication with the sequential electronics in turn takes place via the communication unit. For example, with the aid of the signal-generating unit, analog, position-  
15 dependent signals are generated in known manner from the scanning of a suitable measuring graduation and suitably conditioned in order to be transmitted in serial form via the communication unit to the sequential electronics. The internal interface unit is provided in order to be able to  
20 flexibly combine greatly differing communication units with greatly differing signal-generating units within the framework of a modular system concept.

In such an architecture, the transmission of a measurement-  
25 data request instruction from the sequential electronics to the signal-generating unit and its execution by the signal-generating unit, i.e. the actual measured-value acquisition, must be regarded as fundamentally time-critical. For example, via the measurement-data request instructions, instantaneous  
30 positional data are fetched from the position-measuring device for control purposes. To ensure high control performance on the side of the sequential electronics, it is desirable to

acquire measurement data, or more precisely, positional data, in a manner as free of delay as possible.

Therefore, the object of the present invention is to indicate 5 a method for operating a position-measuring device as well as a corresponding position-measuring device, where within the architecture described above, it is possible to ensure execution of a measurement-data request instruction on the side of the position-measuring device with as little delay as 10 possible.

The first-indicated objective is achieved by a method having the features set forth in Claim 1.

15 Advantageous specific embodiments of the method according to the present invention are derived from the measures delineated in the claims dependent upon Claim 1.

20 The second objective is achieved by a position-measuring device having the features set forth in Claim 8.

Advantageous specific embodiments of the position-measuring device according to the present invention are derived from the measures delineated in the claims which are dependent upon 25 Claim 8.

According to the present invention, particularly with respect to the time-critical transmission to and execution of measurement-data request instructions by the signal-generating 30 unit, it is now provided to bypass the internal interface unit of the position-measuring device and to transmit the corresponding instructions to the signal-generating unit in a fashion as free of further time delay as possible. An additional signal-processing time possibly resulting in the 35 interface unit can therefore be avoided for the time-critical

measurement-data request instructions; a time-determined execution of measurement-data request instructions is ensured.

The measures of the present invention can be used in conjunction with the most varied types of position-measuring devices, regardless of whether they are incremental or absolute position-measuring devices, and regardless of the specific scanning principle and signal-generating principle.

10 Further advantages of the present invention and details pertaining thereto are derived from the following description of the attached drawing, whose figures show:

15 Fig. 1 a schematized block diagram of one possible specific embodiment of the position-measuring device according to the present invention in conjunction with a sequential electronics;

20 Fig. 2 a preferred specific embodiment of a position-measuring device according to the present invention;

25 Fig. 3 a signal diagram of the time sequence of a measurement-data request when working with a position-measuring device according to Figure 2.

30 Figure 1 shows a schematized block diagram of one possible specific embodiment of position-measuring device 10 according to the present invention in conjunction with a sequential electronics 100. In this context, for reasons of better clarity, the various components of the overall system are indicated only in highly schematized fashion.

35 For example, position-measuring device 10 may be in the form of a known incremental or absolute position-measuring system used for determining the position of two objects movable relative to each other, for instance, on a machine tool. In

such an application, a numerical machine-tool control acts as sequential electronics.

5 Data is transmitted between position-measuring device 10 and sequential electronics 100 via a data channel 50 in bidirectional, serial form. To that end, data channel 50 includes two first signal-transmission lines 51, 52, indicated in schematized fashion, via which data is transmitted in the direction indicated by the arrows. In principle, however, 10 data channel 50 may also be constructed differently.

On the side of position-measuring device 10, to handle the data exchange with sequential electronics 100, a schematically indicated communication unit 12 is provided on the input side, 15 which is responsible both for the transmission and the reception of the specific data to and from sequential electronics 100. Communication unit 12 may be constructed differently depending on the interface physics selected or the interface protocol used. That is to say, the present 20 invention may be used in conjunction with widely varied interface concepts and, if desired, bus concepts.

In Figure 1, communication unit 12 is indicated in schematic form as merely a single unit, but in practice may have a 25 markedly more complex design. Thus, in principle, the term communication unit is intended to include all necessary structural elements and components on the side of the position-measuring device that are needed for communication with the sequential electronics. In addition to interface-specific protocol components, line drivers, line receivers, transmitters, controllers, clock-data recovery modules, they 30 may include a plurality of further hardware and software elements, right up to the necessary plug-in connections, etc.

To generate the actual measurement data, position-measuring device 10 of the present invention also includes a signal-generating unit 11, likewise only indicated in schematized fashion. Via it, measurement data, especially positional data, are generated in the position-measuring device. In this context, for instance, positional data may be generated from the scanning of a measuring graduation (not shown) using a scanning unit that is movable relative to the measuring graduation and includes suitable scanning elements. Many different known variants come into consideration as scanning principles, thus, for example, optical, magnetic, capacitive or inductive scanning, via which in each case position-dependent analog signals are able to be generated. Moreover, the generated positional data may involve widely varied types of positional data, like, for instance, incremental positional data, absolute positional data, etc. Because of the diverse possibilities for generating the respective positional data, the signal-generating unit was only indicated schematically in Figure 1.

Furthermore, signal-processing means 15, via which the generated -- for the most part analog -- measurement data or positional data are further processed, may optionally be disposed in respective position-measuring device 10. There are also widely varied possibilities for further processing the generated positional data, depending upon the type of position-measuring device and its application. For example, it may involve signal preprocessing, signal filtering signal matching before, for instance, an A/D conversion and subsequent digital signal processing are also carried out. Highly diverse methods may be provided within the framework of a digital signal processing as well, for example, a signal correction, a signal interpolation, a signal monitoring, a signal diagnosis, etc. Because of these varied possibilities for signal processing, signal processing means 15 is again

indicated only schematically in Figure 1; consequently, signal processing unit 15 may also include several components.

As already indicated at the outset, position-measuring device 10 of the present invention also includes an internal interface unit 13. Internal interface unit 13 is not to be understood as a physical, but rather as a logic unit which is arranged between signal-generating unit 11 and optional signal-processing means 15 on one side and communication unit 12 on the other side. Internal interface unit 13 proves to be useful, particularly with respect to a modular system design, since many different variants for signal generation are then able to be flexibly combined with the different signal-transmission principles in the direction of sequential electronics 100. In other words: widely different variants of signal-generating units 11 and, if desired, signal-processing units 15 may be flexibly combined with widely different communication units 12, depending on the application.

To that end, in known manner, internal interface unit 13 may be in the form of a bidirectional interface, many different interface architectures again coming into consideration. In Figure 1, this is indicated by an addressing channel 21 and a data-transmission channel 22.

Within the scope of the present invention, it is now provided to transmit in particular the time-critical measurement-data request instructions RQ, which are transmitted from sequential electronics 100 via signal-transmission line 51 of data channel 50, to signal-generating unit 11, while bypassing internal interface unit 13, and to bring about their execution, i.e. the measurement-data acquisition, as promptly as possible at the signal-generating unit. As indicated in Figure 1, this is accomplished, for instance, by transmitting measurement-data request instructions RQ via a separate data

channel 14 in the direction of signal-generating unit 11, thus not via internal interface unit 13 otherwise used for signal transmission in position-measuring device 10. For example, separate data channel 14 may be in the form of a separate 5 connecting line which bypasses internal interface unit 13.

As is apparent from the two alternative, separate data channels 14.a, 14.b in Figure 1, provision may be made to send measurement-data request instructions RQ via data channel 14.a 10 directly to the signal-generating unit; alternatively, it is possible to send measurement-data request instruction RQ via data channel 14.b to signal-processing unit 15. The latter may be provided, for instance, when sequential electronics 100 requests the transmission of measurement data that are derived 15 from the actual positional data. For example, it may involve the measurement data regarding acceleration or jerk that result from the derivation of the positional data; the suitable signal processing and signal conditioning from the positional data is then carried out in signal-processing unit 20 15.

For the bypassing of communication unit 12 described, it is necessary to identify measurement-data request instructions RQ in the data stream transmitted by sequential electronics 100 25 and to separate them. For this purpose, position-measuring device 10 and communication unit 12, respectively, are assigned redirection means in the form of a suitable unit 16 and a separate data channel 14 which takes over this function. In the incoming data stream on signal-transmission line 52, 30 measurement-data request instructions RQ are identified, separated and redirected via data channel 14 in the direction of signal-generating unit 11, bypassing internal interface unit 13. To that end, the separated measurement-data request instructions RQ are suitably conditioned, thus permitting the 35 desired, undelayed transmission to signal-generating unit 11.

The delay otherwise resulting in internal interface unit 13 because of the signal-processing time required there is therefore eliminated based on the measures according to the present invention. Prompt measured-data acquisition is 5 ensured on the side of position-measuring device 10.

Figure 2 shows a preferred specific embodiment of a position-measuring device 10 according to the present invention in detail. For reasons of clarity, communication unit 12, as 10 well as unit 16 which provides the redirection means for measurement-data request instructions RQ, were combined in one data-transmission unit 30. In the same way, signal-generating unit 11 and optional signal-processing unit 15 were combined to form one data-acquisition unit 31. Internal interface unit 15 13, which, as a logic unit, controls the data exchange between data-transmission unit 30 and data-acquisition unit 31, is only indicated schematically. For better understanding, identical components are provided with the same reference numerals in all figures.

20 Data is transmitted from data-transmission unit 30 to data-acquisition unit 31 via an addressing channel 21. In the reverse direction, thus from data-acquisition unit 31 to data-transmission unit 30, data is transmitted via a data-transmission channel 22.

Addressing channel 21 is used for sending data request 30 instructions and for transmitting parameters from data-transmission unit 30 to data-acquisition unit 31. The data are transmitted synchronously with respect to the clock signal on an address clockline ADR\_CLK in the form of serial data packets via n addressing lines AS0-AS(n-1). The number n of addressing lines is arbitrary, powers of the number 2 (1, 2, 4, 8,...) usually being selected in data technology. Further 35 criteria are, for example, the complexity of the transmission

protocol used, the quantity of data to be transmitted, as well as the number of available connections at the data-transmission modules. In this preferred specific embodiment, n=2 was selected.

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In this context, the type of data requested from data-acquisition unit 31 is not limited to positional data or measurement data. Thus, for example, the sending of error messages, warnings and diagnostic values may also be initiated. In addition, parameters which are necessary for the operation of data-acquisition unit 31, e.g. correction values, may be transmitted via addressing channel 21.

Data-transmission channel 22 is used for transmitting requested data from data-acquisition unit 31 to data-transmission unit 30. For that purpose, m data lines D0-D(m-1), as well as one data clockline DATA\_CLK are provided. The number m of data lines is also arbitrary; the same selection criteria are applicable as for the number n of addressing lines. In the example described, m=4.

Data is transmitted on data lines D0-D(m-1) synchronously with a clock signal on data clockline DATA\_CLK. In this context, it is particularly advantageous if the clock signal of address clockline ADR\_CLK, delayed by the signal propagation time in data-acquisition unit 31, is used as the clock signal on data clockline DATA\_CLK, since in this way, a clock signal may easily be obtained for the synchronous data transmission, and therefore it is not necessary to generate a separate clock signal in data acquisition unit 31. The delay between the clock signal of address clockline ADR\_CLK and the clock signal on data clockline DATA\_CLK is usually very small, and in Figure 3, is only indicated by point of time t1', which corresponds to point of time t1 delayed by the signal propagation time.

As described above, measurement-data request instructions RQ are identified from the data stream transmitted by sequential electronics 100, separated and conducted via separate data channel 14 to data-acquisition unit 31. The time gain resulting from this arrangement is clearly discernible in Figure 3.

Figure 3 shows a signal diagram of the time sequence of a measurement-data request. First, at point of time  $t_0$ , a falling edge on separate data channel 14 signals to data-acquisition unit 31 a measurement-data request instruction RQ, and the measurement-data acquisition is started without further time delay. Only after a certain time, which is a function of the processing time in data-transmission unit 30, is a clock signal started on address clockline ADR\_CLK at point of time  $t_1$ . As of point of time  $t_2$ , a serial data packet having the information about the type of requested data is transmitted from data-transmission unit 30 to data-acquisition unit 31 via lines AS0 and AS1 synchronously with the clock signal on address clockline ADR\_CLK.

Since when working with a position-measuring device without the redirection measures of the present invention, point of time  $t_1$  is the earliest point of time at which a measurement-data acquisition can be started, the time gain of the position-measuring device according to the present invention is calculated from the difference between  $t_1$  and  $t_0$ .

When the requested data is ready in data-acquisition unit 31 at point of time  $t_3$ , the transmission to data-transmission unit 30 begins via data lines D0 - D3 in the form of a serial data packet. Without the measures of the present invention, point of time  $t_3$  would be delayed by the difference between  $t_1$  and  $t_0$ , i.e., the transmission of data could only begin

perceptibly later. As already described, the transmission proceeds synchronously with respect to the clock signal on data clockline DATA\_CLK. When the data transmission is ended at point of time t4, a rising edge on separate data channel 14 5 signals that measurement-data request instruction RQ is executed. At the end of the data transmission, the clock signals on address clockline ADR\_CLK and data clockline DATA\_CLK are also stopped.

10 The structure of the serial data packets can be a matter of choice. For example, in addition to the data that is actually to be transmitted, they may also contain information concerning the contents and size of the data packet, status information or checksums.

15 Since the communication between data-acquisition unit 31 and data-transmission unit 30 proceeds on two separate data channels, it is possible to request further data even before the end of the data transmission.

20 Besides the elucidated exemplary embodiments, there are, of course, other embodiment alternatives within the scope of the present invention.